Astigmatic Refractive Error: The Power Cross

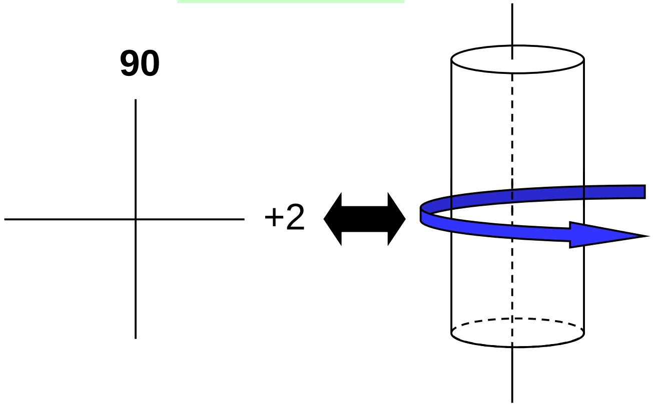
Basic Optics, Chapter 15

Power Cross

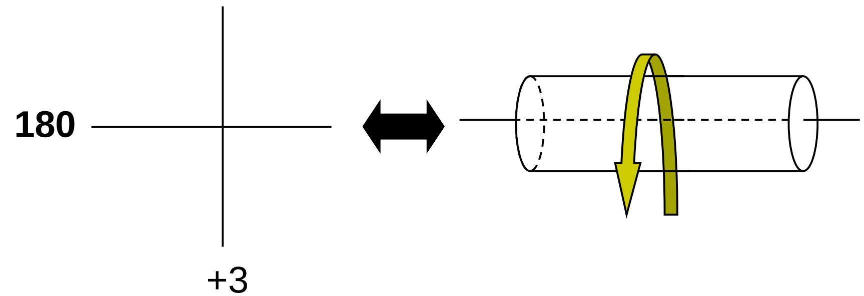
- The power cross is a concise and convenient format for representing astigmatic error (and its correction)
- It's also a source of considerable confusion for ophthalmologists-in-training
- Trust me when I say that, once you understand it, the Power Cross is your friend!

Power Cross

+2 x 090

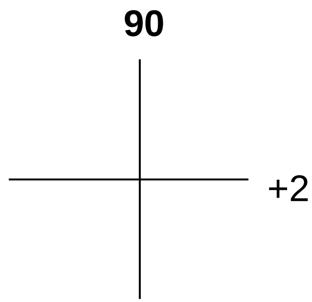


+3 x 180

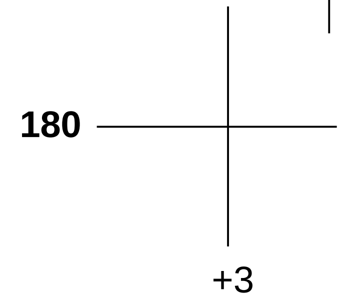


A cylinder can be represented on a power cross. Note the notation conventions: Power is recorded on the *meridian* of power, which is 90º away from the *axis* of power. In this way, a power cross provides an efficient summary of the clinically relevant refractive properties of the cylinder.

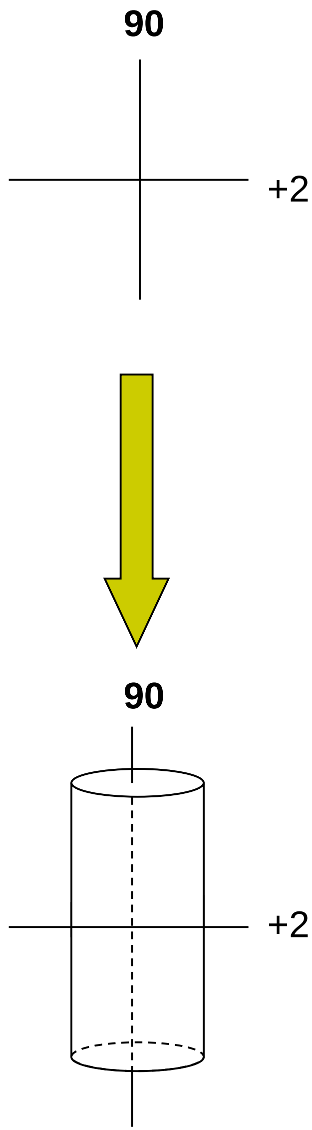
Power Cross



If you have difficulty remembering the conventions of power-cross notation (i.e., that the power is notated at the meridian of power, 90^o away from the axis of power)…

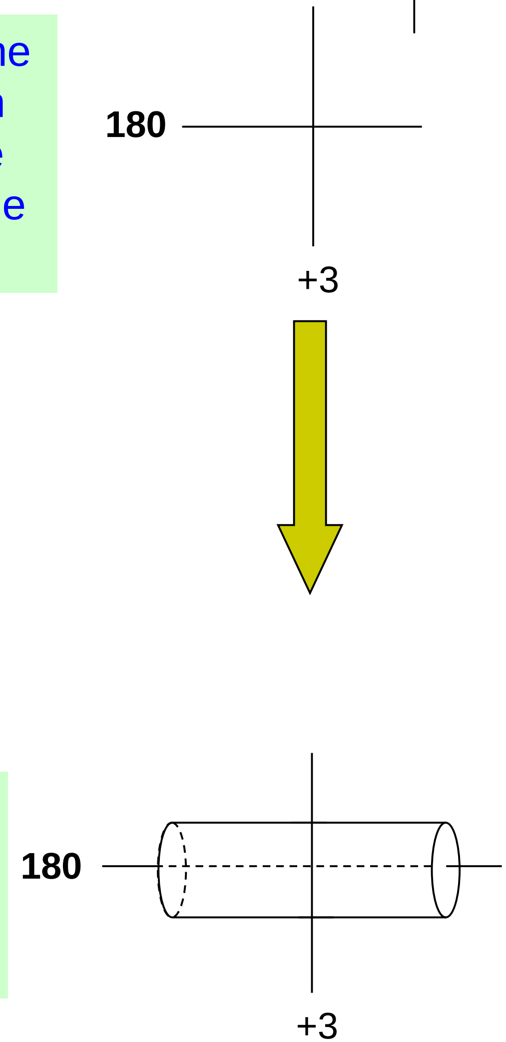


Power Cross



If you have difficulty remembering the conventions of power-cross notation (i.e., that the power is notated at the meridian of power, 90º away from the axis of power)…

…then picture it **this** way; i.e., as a cylinder oriented along the notated axis of power. Visualized this way, the meridian of power is obvious!



Cylinder ***combinations*** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90^{o} away from its axis.

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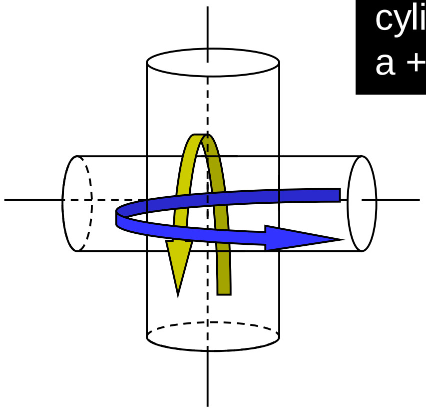
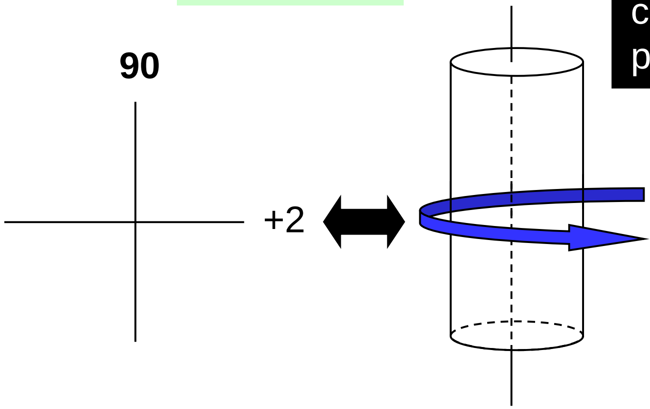
Say you have a single lens that is the equivalent of two cylinders—a +2x090 and a +3x180.



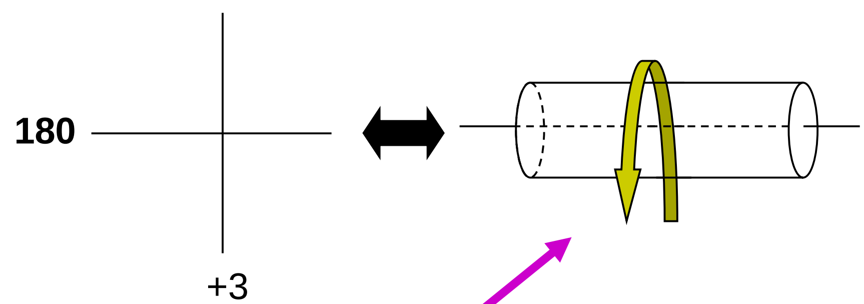
Cylinder ***combinations*** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90º away from its axis.

+2 x 090



The component cylinders can be written as individual power crosses…

+3 x 180



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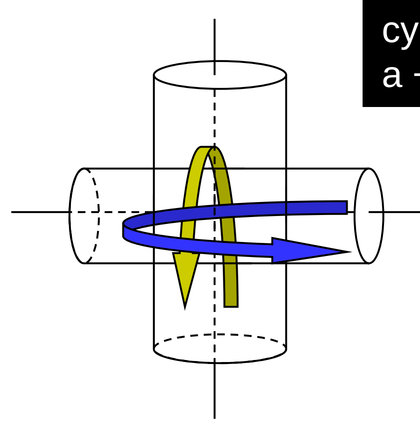
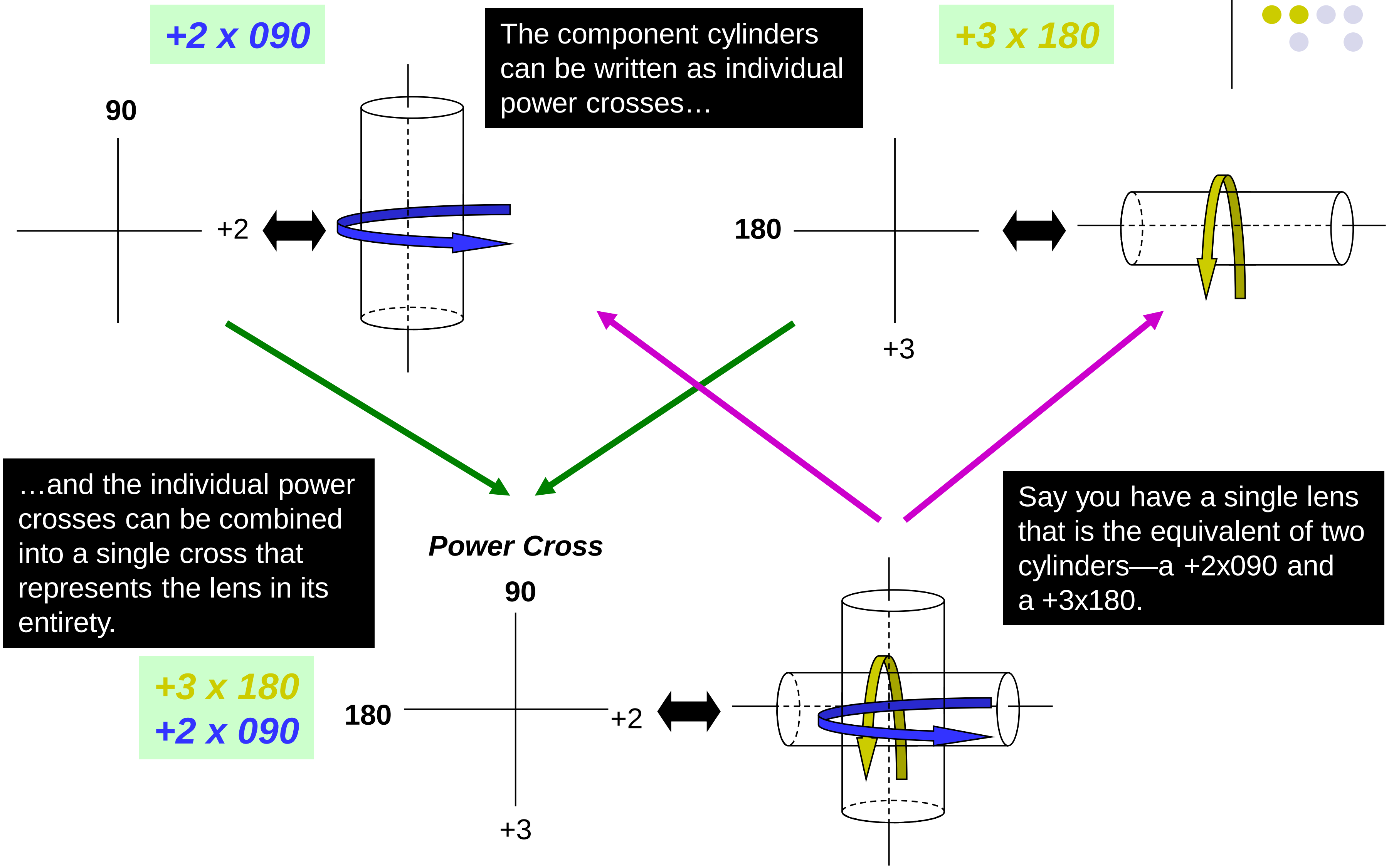


Cylinder ***combinations*** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90º away from its axis.

The component cylinders can be written as individual power crosses…

…and the individual power crosses can be combined into a single cross that represents the lens in its entirety.

Say you have a single lens that is the equivalent of two cylinders—a +2x090 and a +3x180.

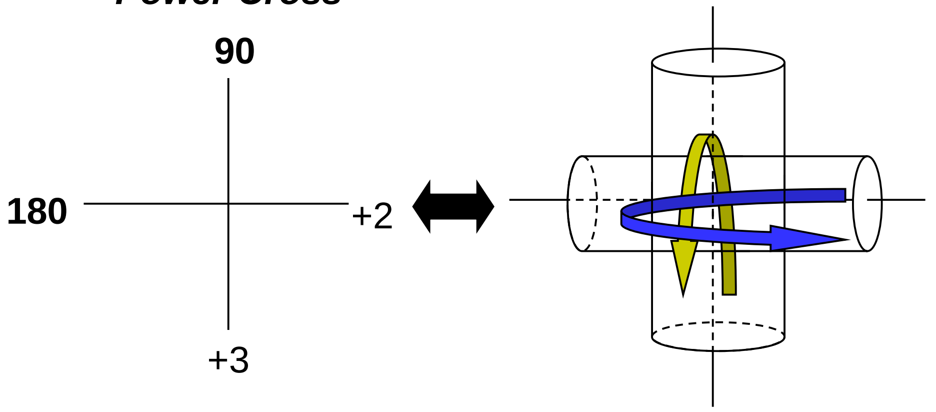


Power Cross

Here's where confusion concerning power crosses creeps in. *The most common mistake is to treat the power cross like a spectacle/CL prescription*. In the present example, the power cross could be (mis)interpreted as representing the spectacle correction *+3 +2 x 090,* or perhaps *+2 +3 x 180.*

Power Cross

+3 x 180
+2 x 090



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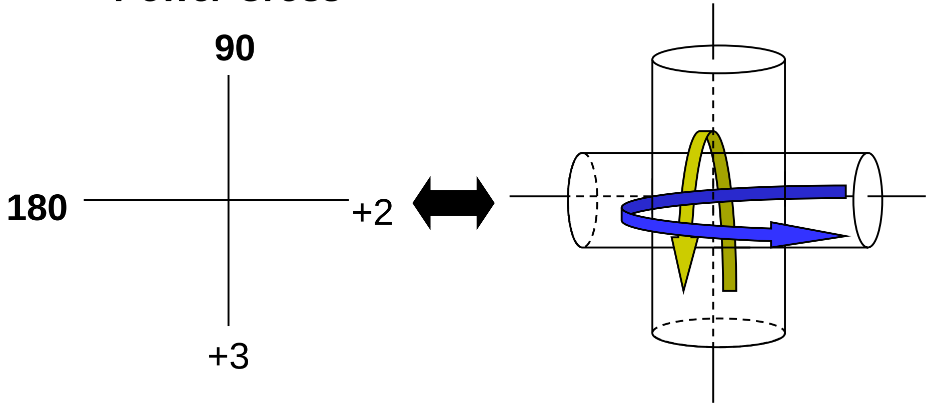
Note that *+3 +2 x 090* and *+2 +3 x 180* **cannot** both be correct, as they are not equivalent refractions:

***+3 +2 x 090** converts to +5 -2 x 180 (not **+2 +3 x 180**); likewise,*
***+2 +3 x 180** converts to +5 -3 x 090 (not **+3 +2 x 090**)*

Power Cross

+3 x 180
+2 x 090



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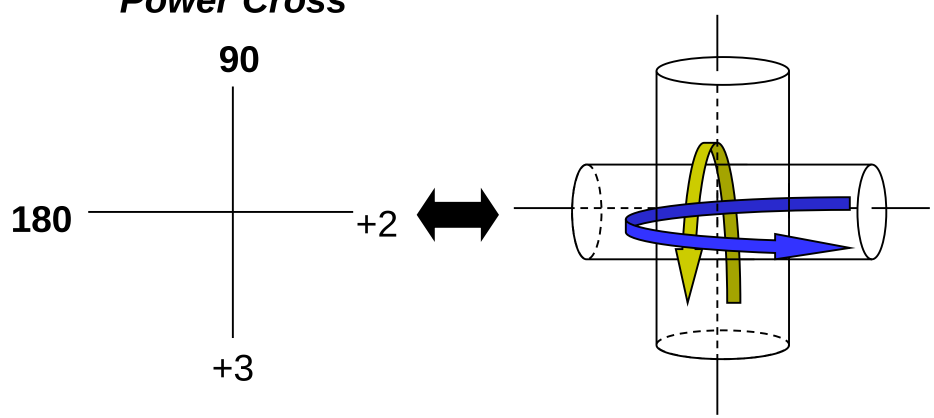
What's the difference between a power cross and a prescription? *A prescription is written in* ***spherocylindrical*** *form*, *whereas a power cross is written in* ***cylinder*** *form only*. If you break down the word 'spherocylindrical,' you can see that a prescription is composed of a sphere power (the first number) and a cylinder power (the second number, and its axis). In contrast, a power cross simply states the power and axes of two cylinders—no spherical power is implied.

+3 x 180
+2 x 090

Power Cross



Power Cross

This states 'the entire lens has a base power of +3, and +2 of cylinder power with axis 090 has been added.' (Note that this means the lens has a total of +5D power at axis 090--the base +3 plus the cylindrical +2.)

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+3 x 180
+2 x 090

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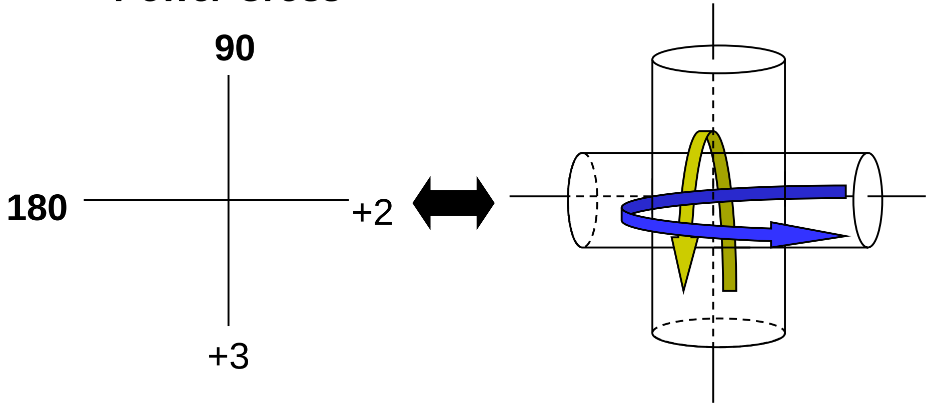

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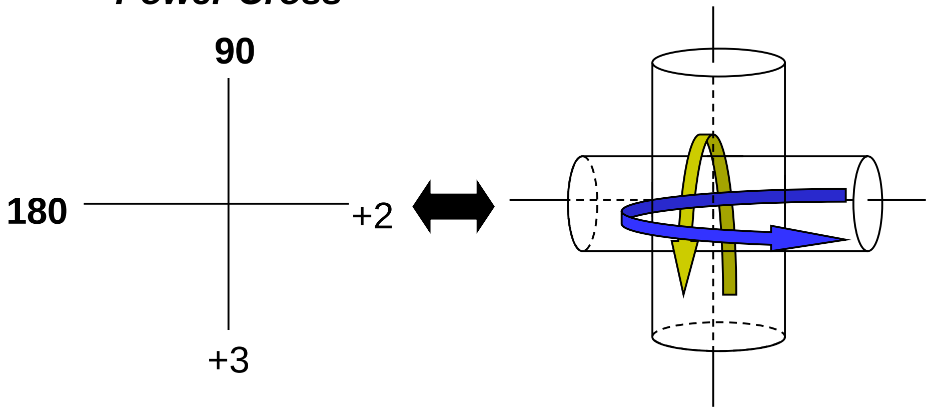
Power Cross

+3 x 180
+2 x 090



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You can see that neither of these is a proper interpretation of the power cross below

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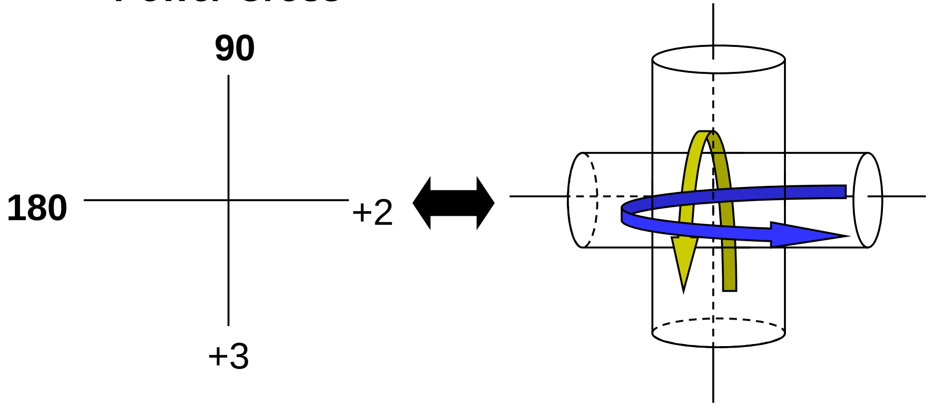
+3 x 180
+2 x 090

Power Cross



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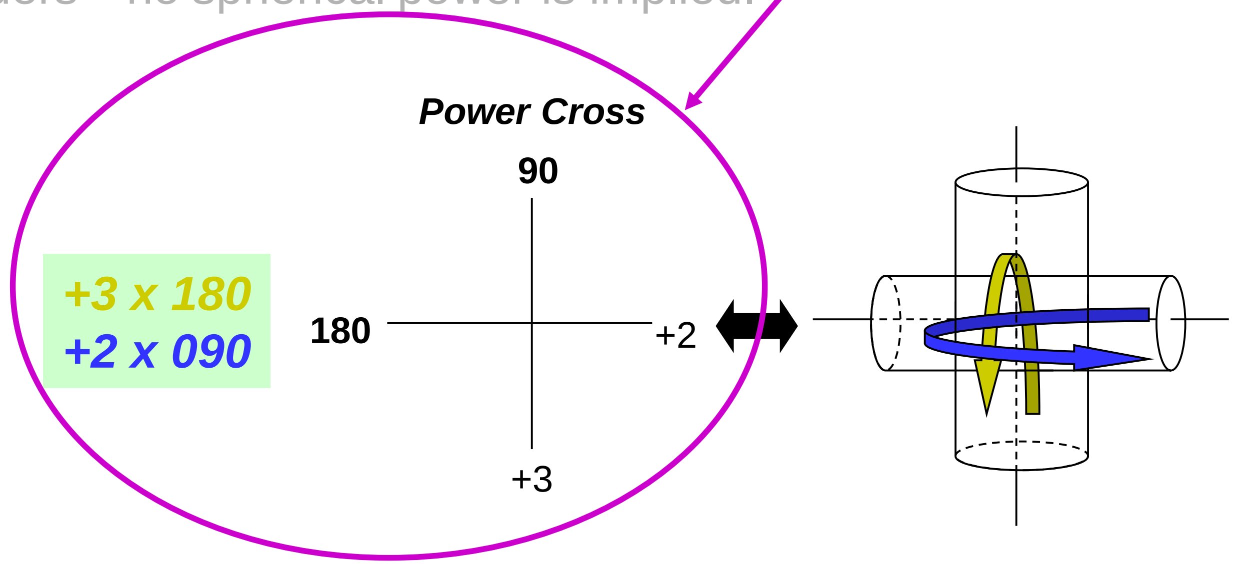

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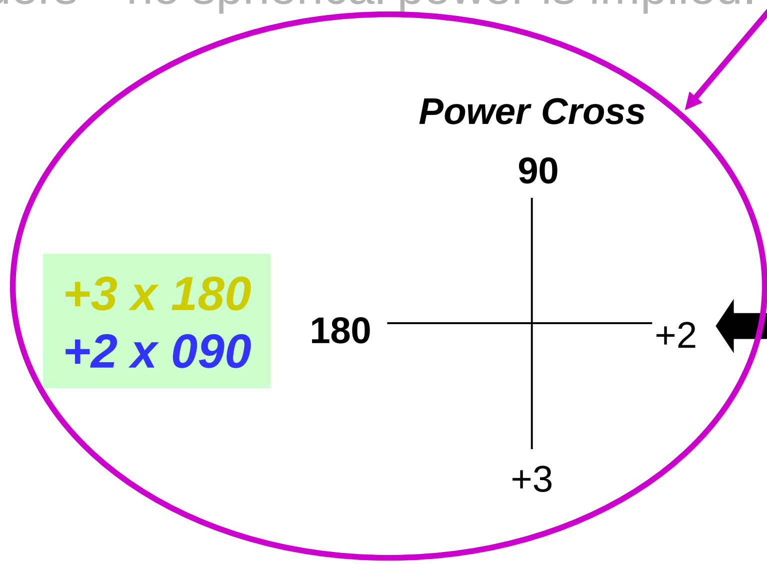
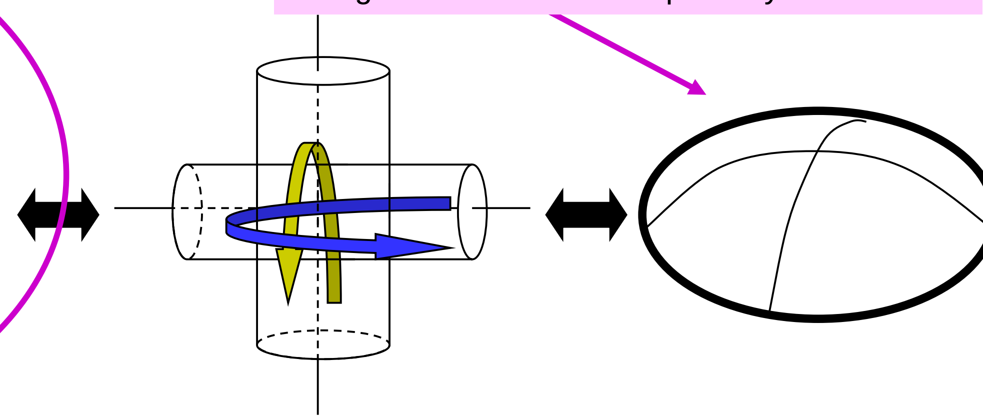
This is true even if the power-cross format is being used to describe a spherocylindrical lens!



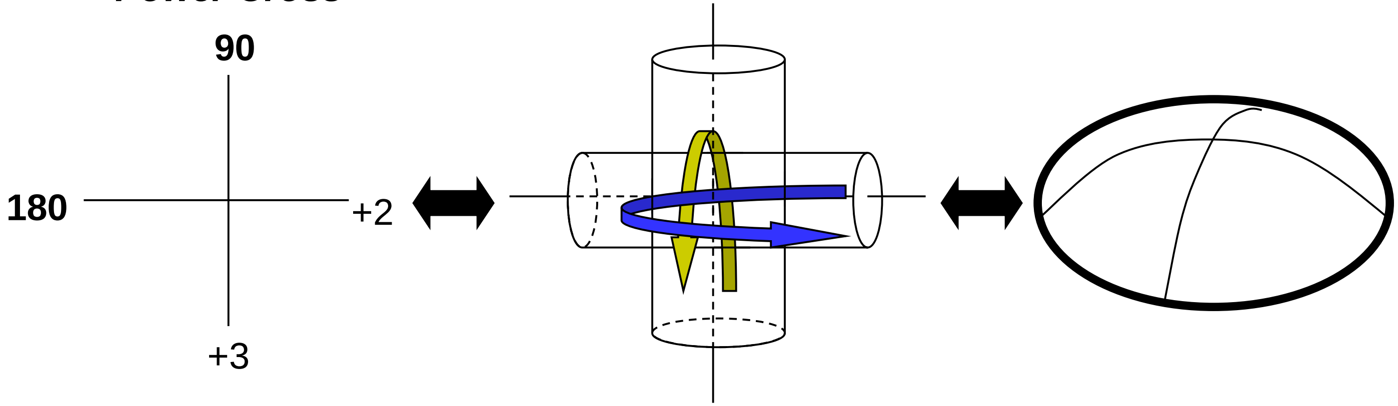


Power Cross

A power cross can easily be converted to its spherocylindrical equivalent. Simply pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed.

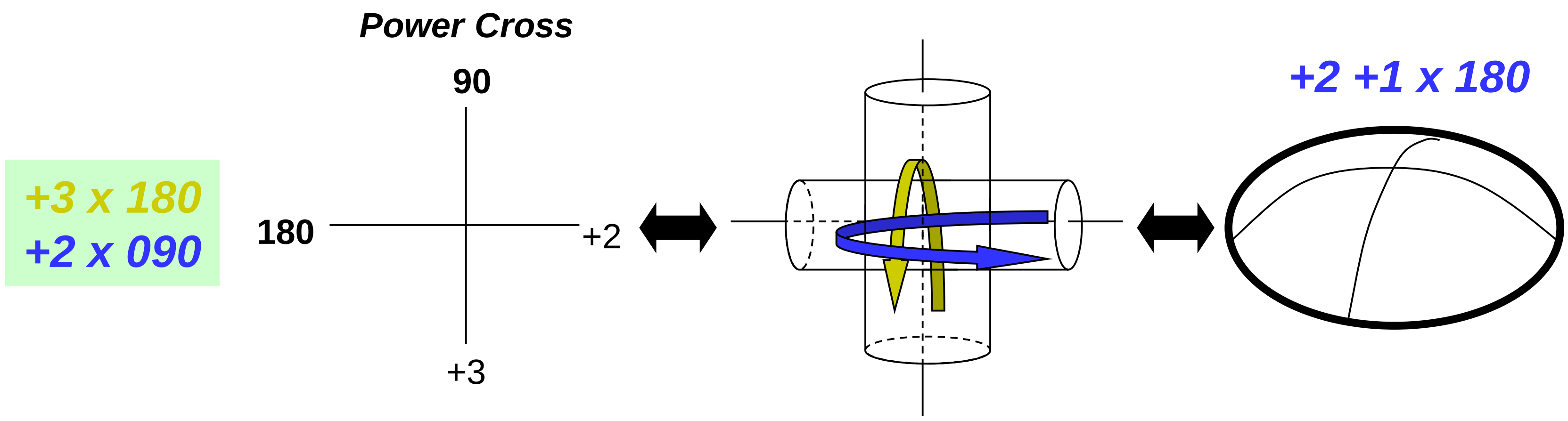
Power Cross

+3 x 180
+2 x 090



Power Cross

A power cross can easily be converted to its spherocylindrical equivalent. Simply *pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed.* For instance, in the present example we could use +2D as our base sphere. The power needed at axis 090 is now in place. What about at 180? Since there is already +2D present there (courtesy of our +2D base sphere), we need an additional *+1 x 180* to produce the +3D power needed in this axis. Thus, if using a +2D base sphere lens, the spherocylindrical (prescription) equivalent of our power cross is *+2 +1 x 180.*



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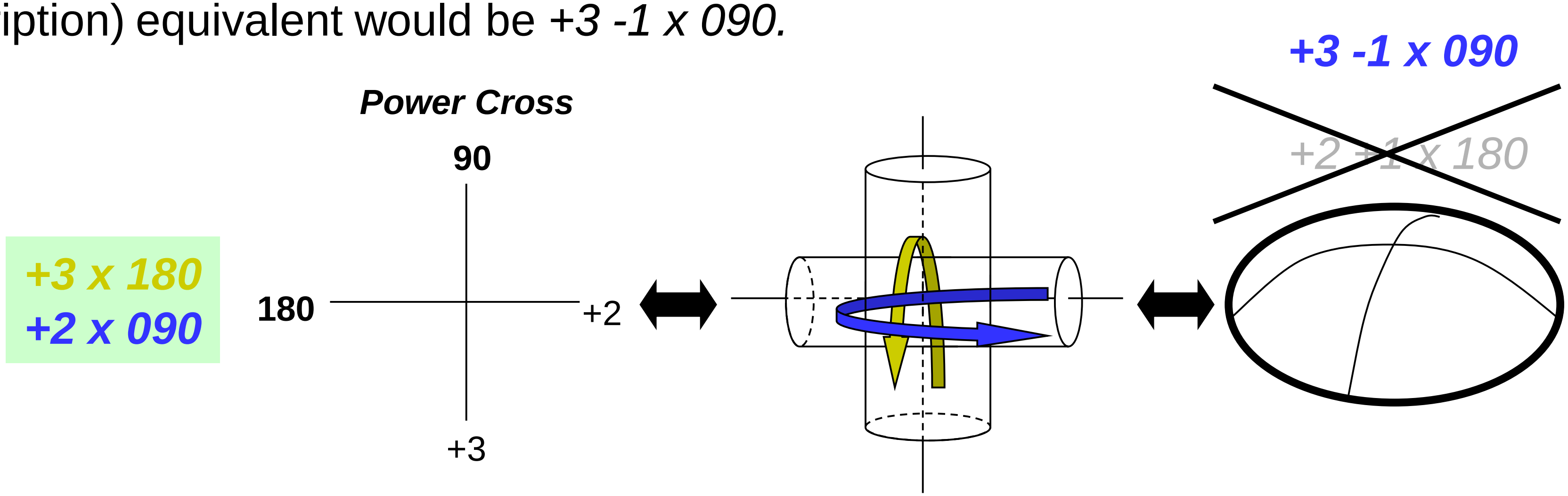
Or, we could use the +3D cylinder to create our base sphere. Note that this provides 1D of plus more than is needed at axis 090. To offset this excess plus we need *-1 x 090* to produce the power needed in this axis. Thus the spherocylindrical (prescription) equivalent would be *+3 -1 x 090.*



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A power cross can easily be converted to its spherocylindrical equivalent. Simply *pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed.* For instance, in the present example we could use +2D as our base sphere. The power needed at axis 090 is now in place. What about at 180? Since there is already +2D present there (courtesy of our +2D base sphere), we need an additional +*1 x 180* to produce … us, if using a +2D base sphere lens, the … ent of our power cross is ***+2 +1 x 180***.

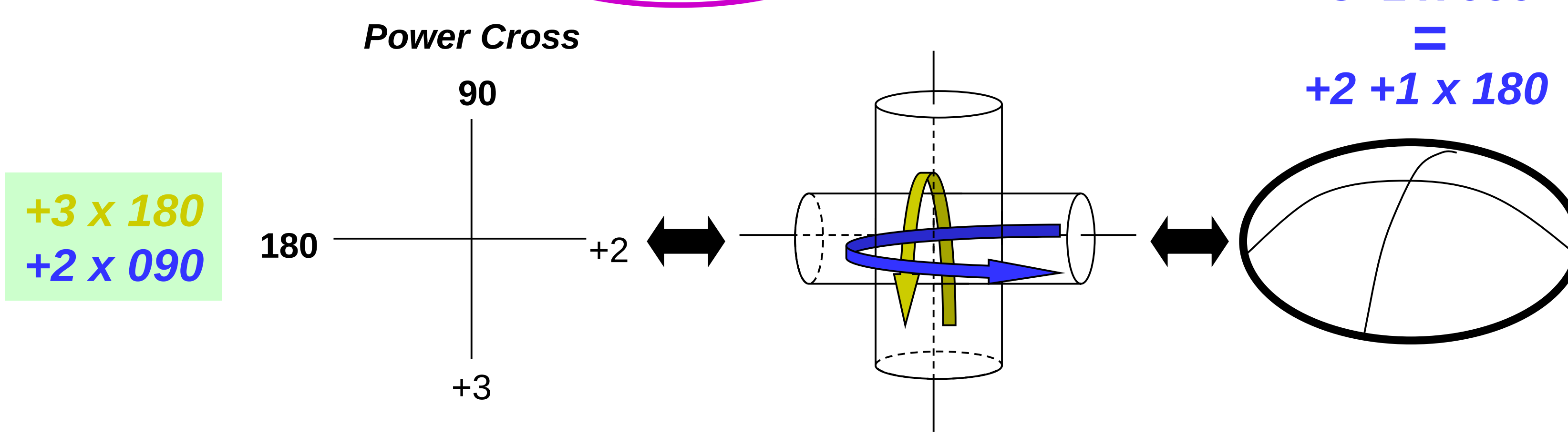
… reate our base … here. Note that this provides 1D of plus more than is needed at axis 090. To offset … s excess plus we need -*1 x 090* to produce the power needed in this axis. Thus the spherocylindrical (prescription) equivalent would be ***+3 -1 x 090***.

=

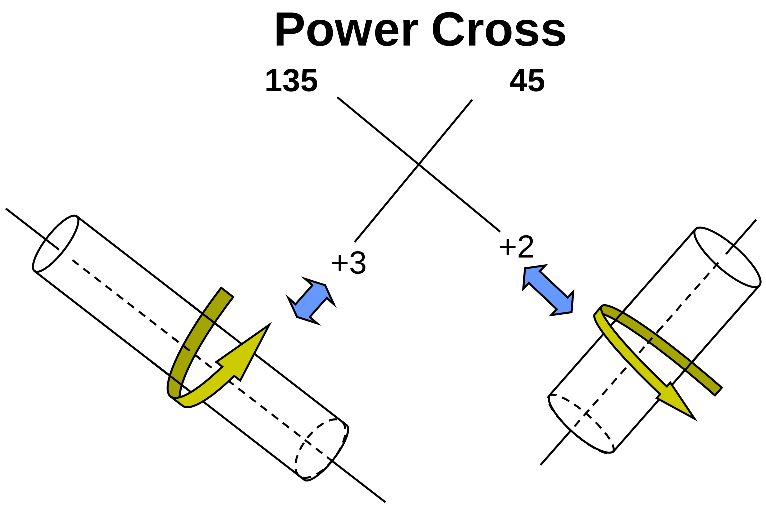
Note the two prescriptions are equivalent:

+2 +1 x 180 *converts to* ***+3 -1 x 090****, and*
+3 -1 x 090 *converts to* ***+2 +1 x 180***

+3 -1 x 090
=
+2 +1 x 180



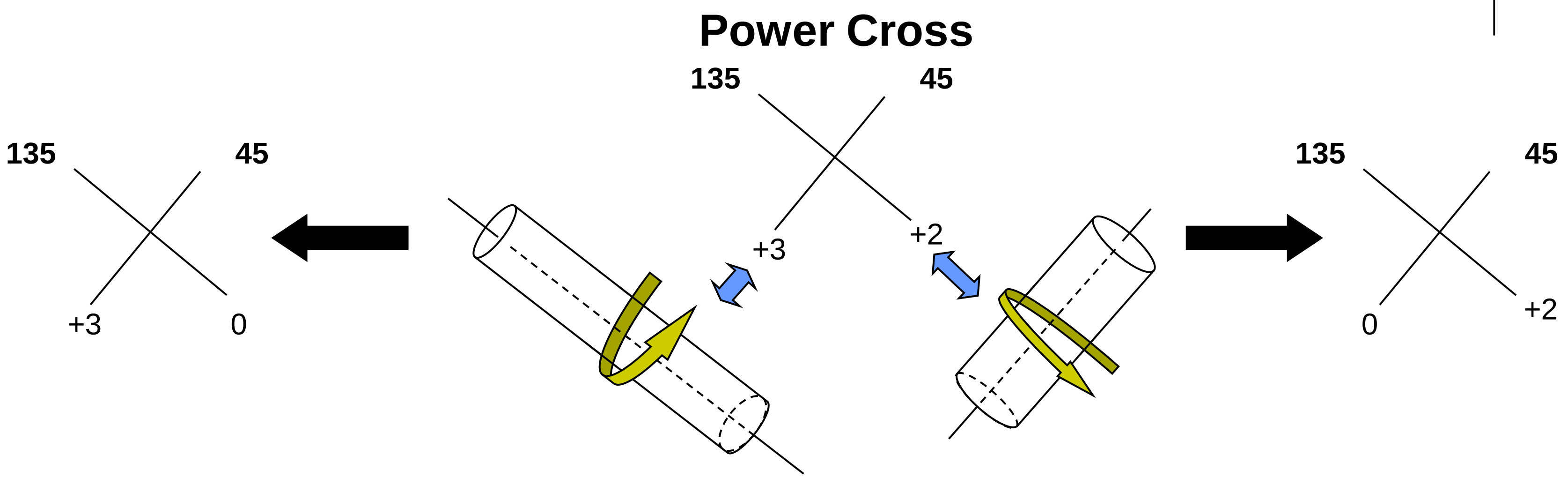
Power Cross



Let's take more of a cookbook approach to the conversion of a power cross to a spherocylindrical correction. Here's how to convert a power cross into a spherocylindrical prescription in four easy steps!

Power Cross

1. Separate the cylinders.



Power Cross

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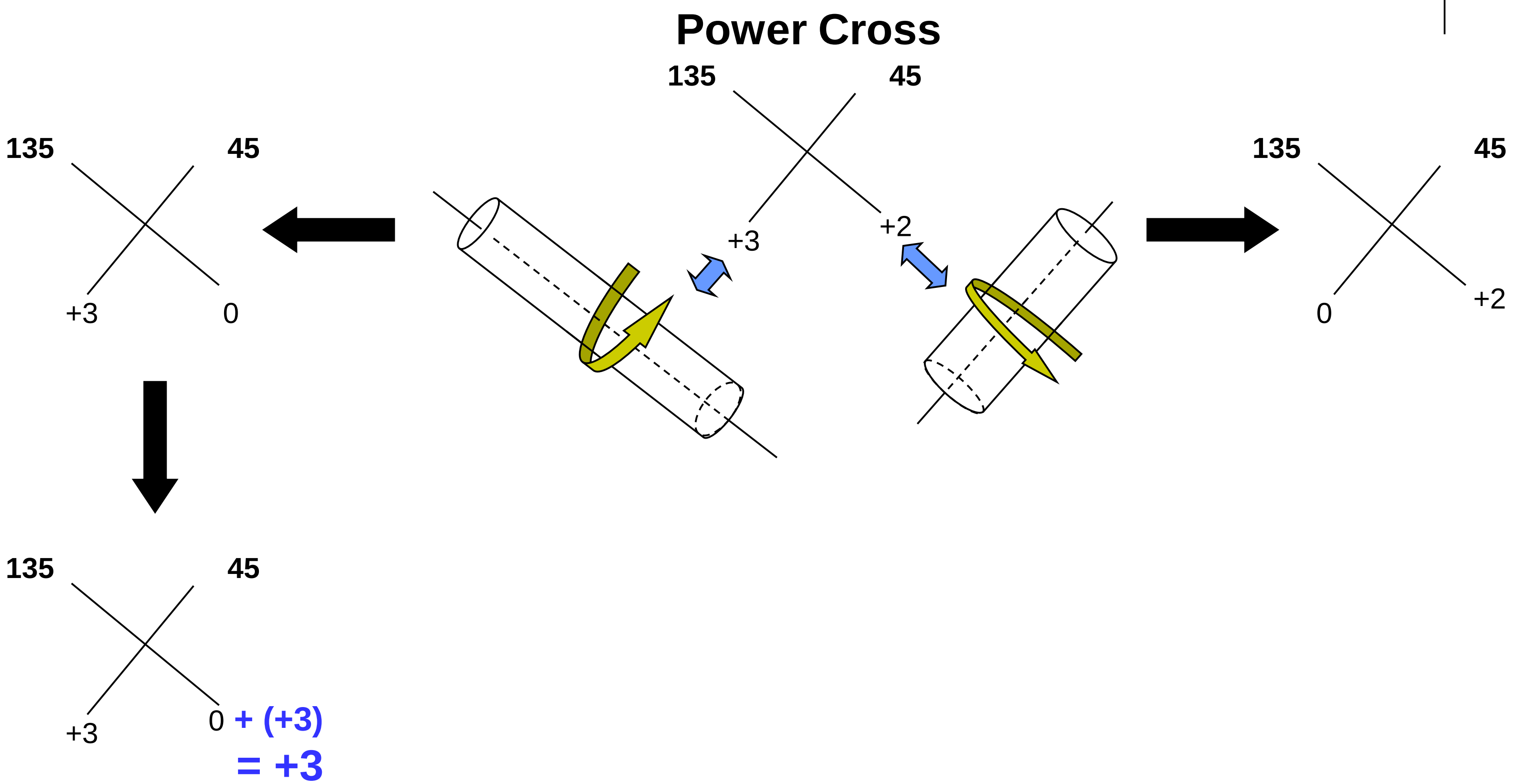

2. Make one cylinder the sphere by adding its power to the other arm.

Power Cross

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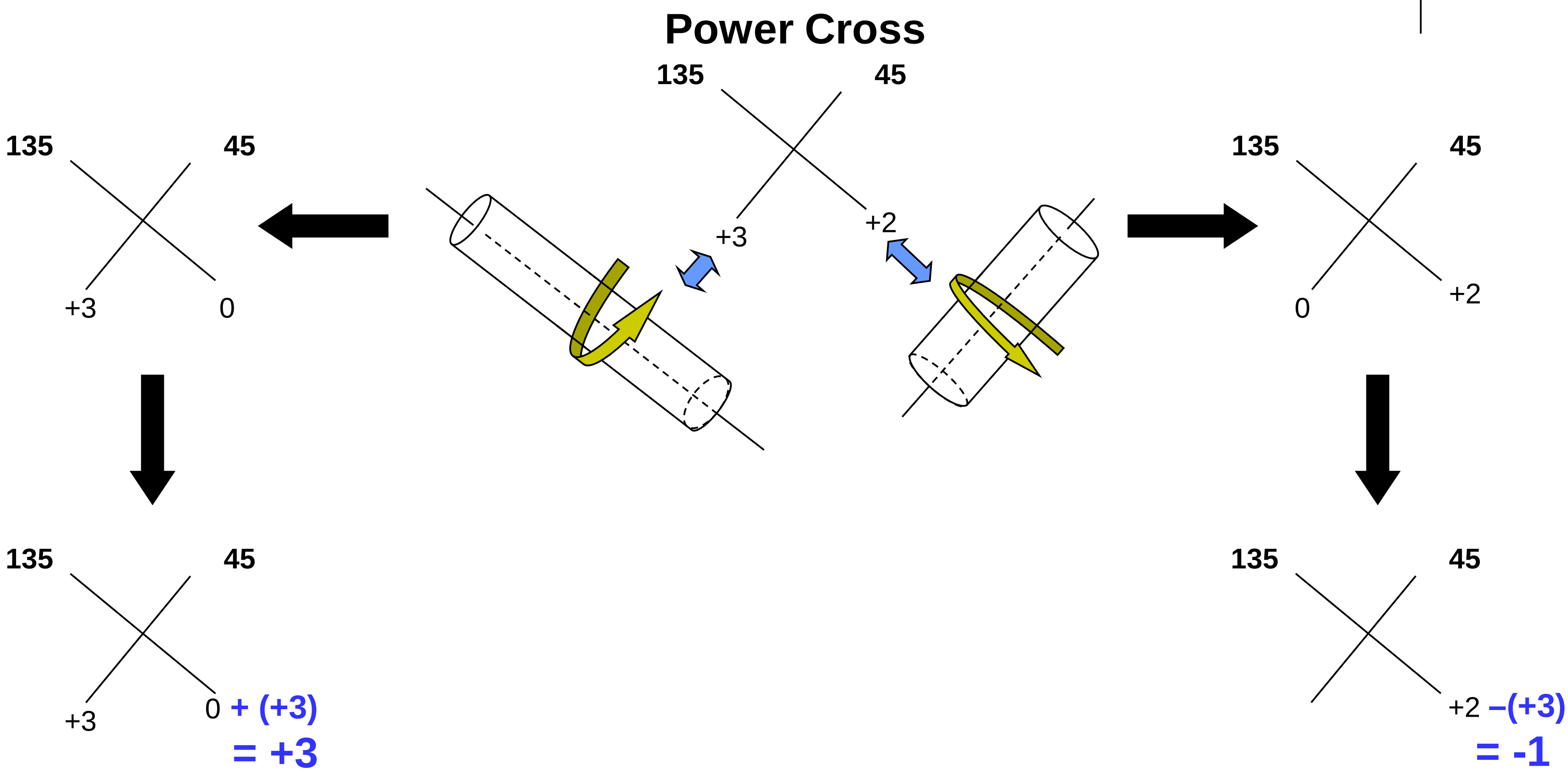

2. Make one cylinder the sphere by adding its power to the other arm.

3. Subtract the same amount from the same arm of the other cylinder.

Power Cross

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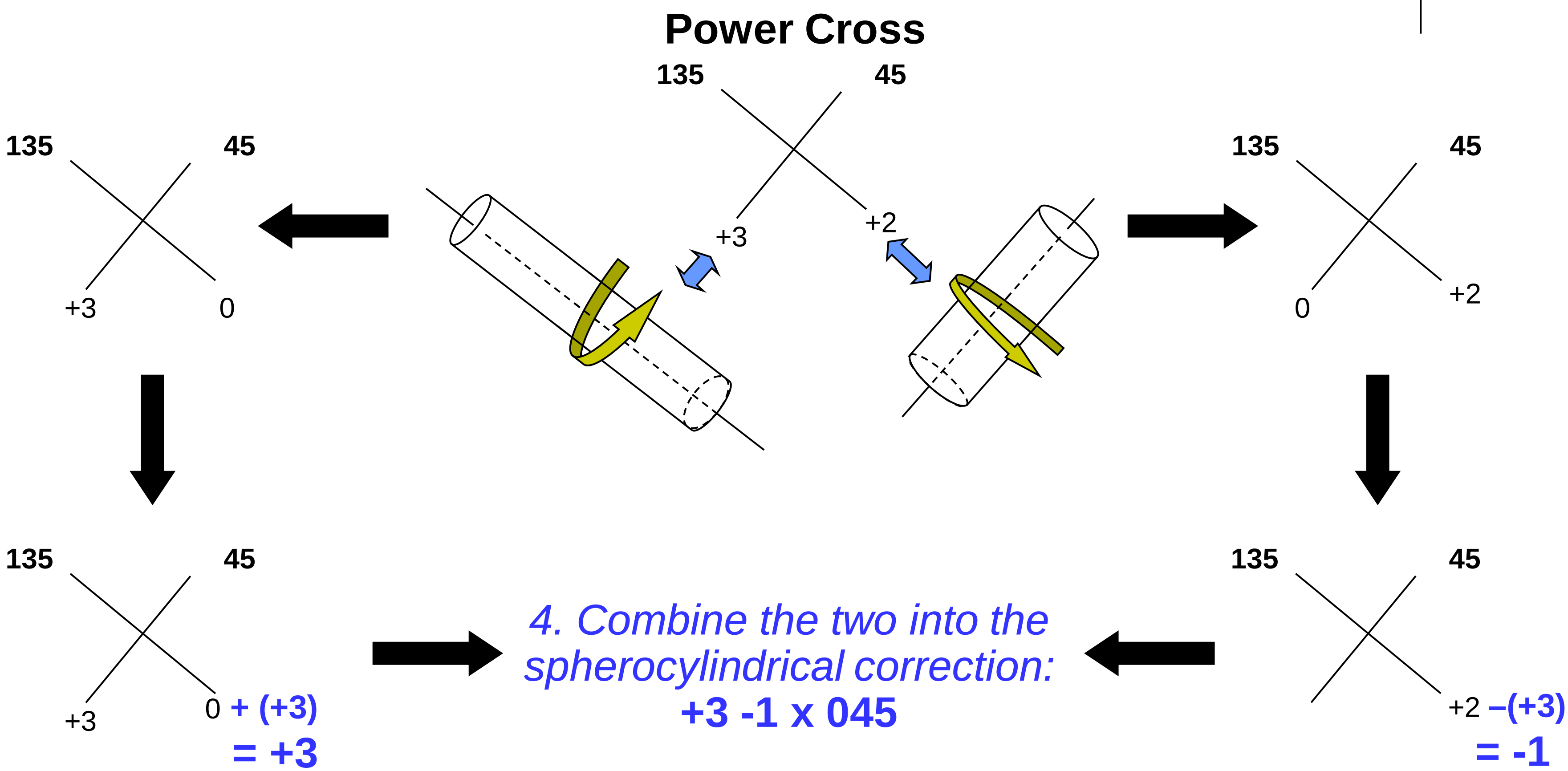


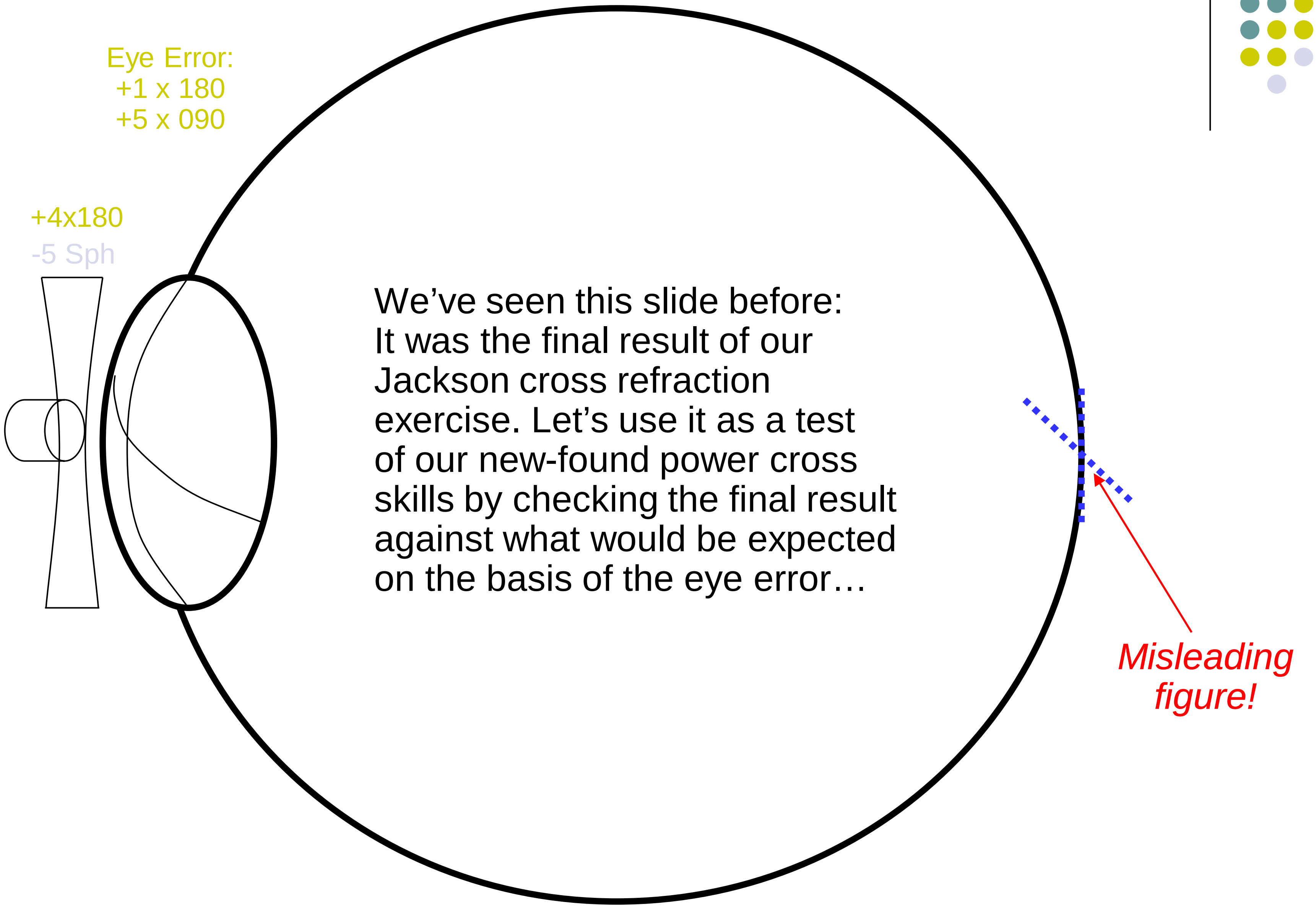
2. Make one cylinder the sphere by adding its power to the other arm.

3. Subtract the same amount from the same arm of the other cylinder.

4. Combine the two into the spherocylindrical correction:

+3 -1 x 045

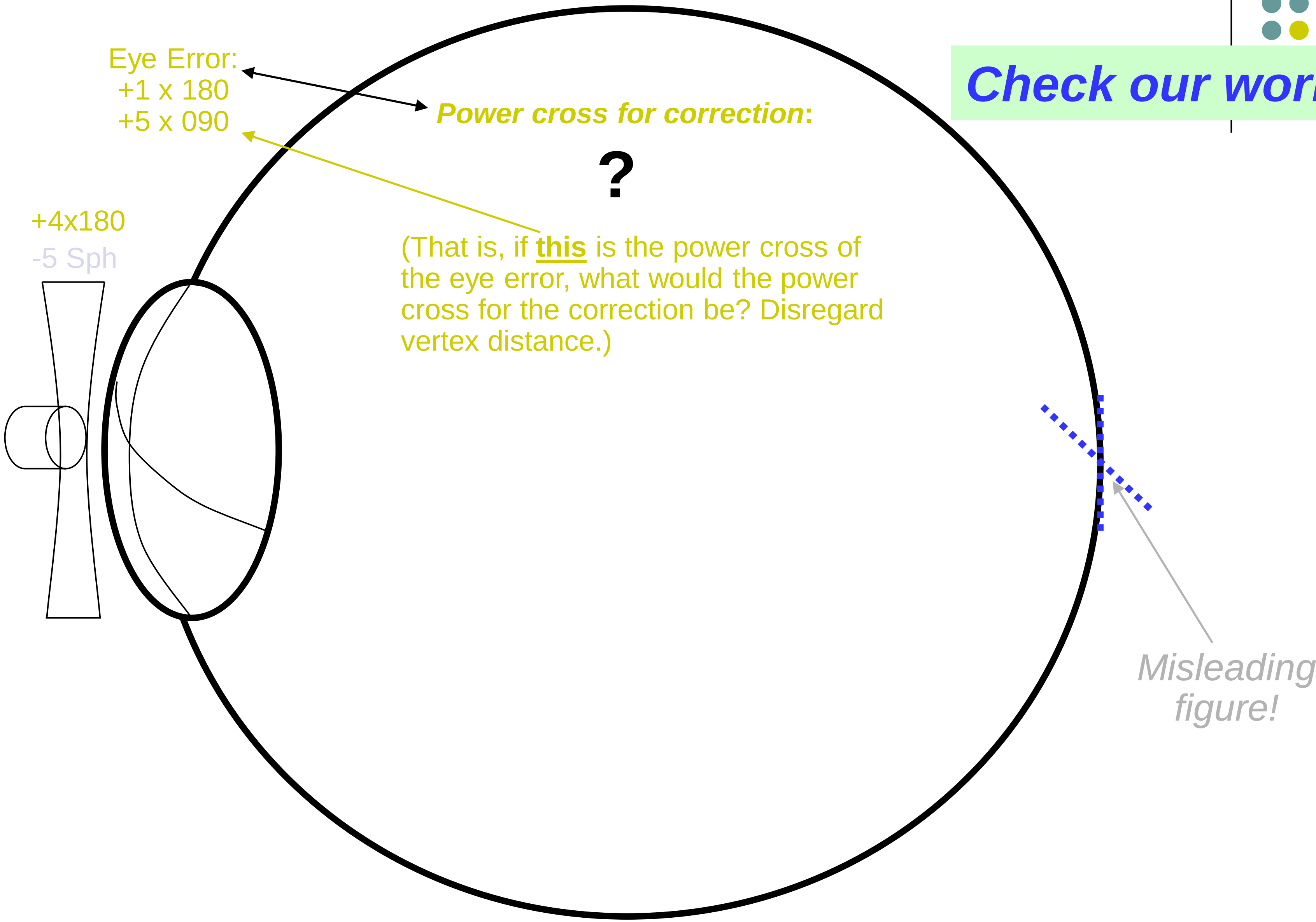
Power Cross



We've seen this slide before: It was the final result of our Jackson cross refraction exercise. Let's use it as a test of our new-found power cross skills by checking the final result against what would be expected on the basis of the eye error…

Power Cross

Check our work…



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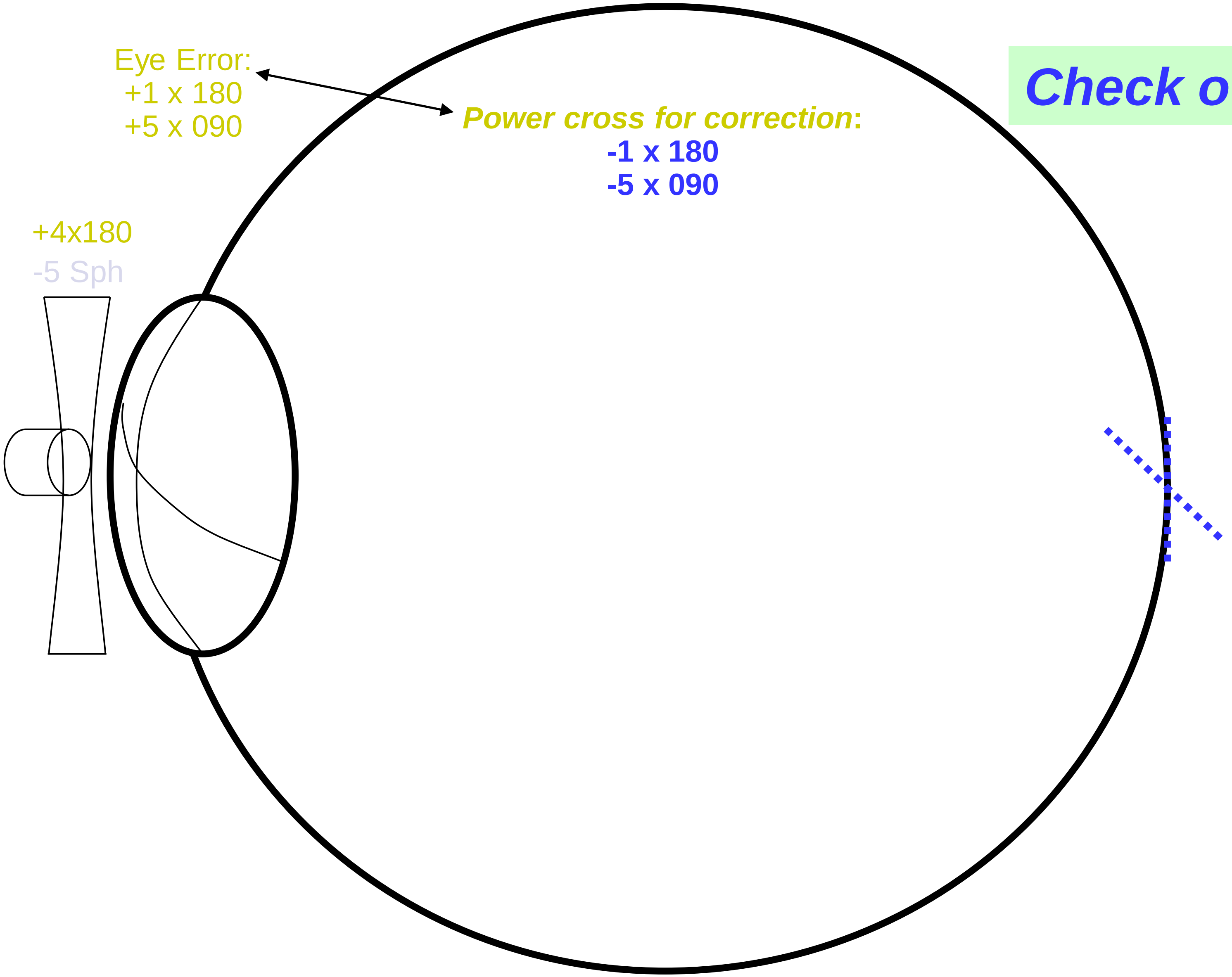

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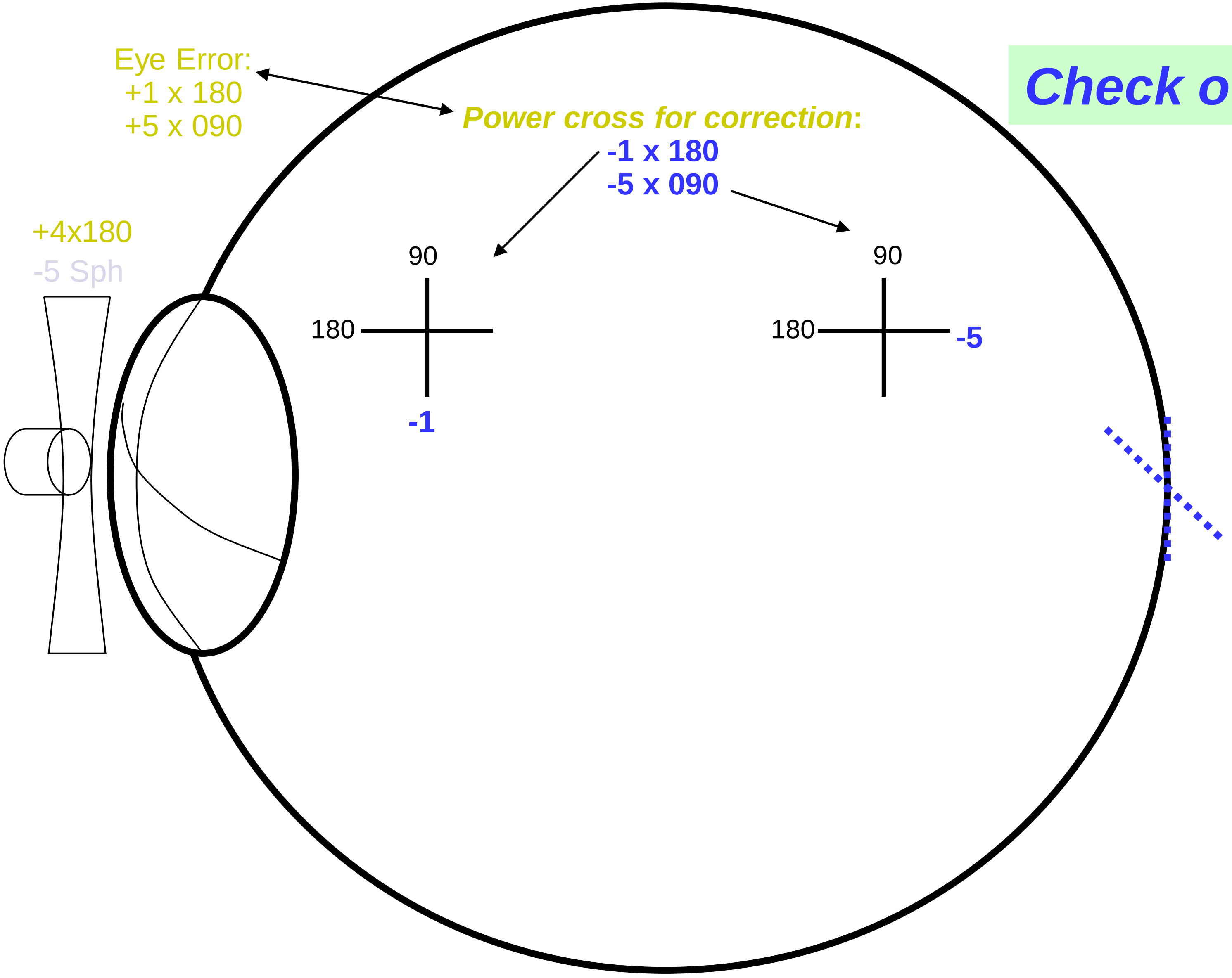
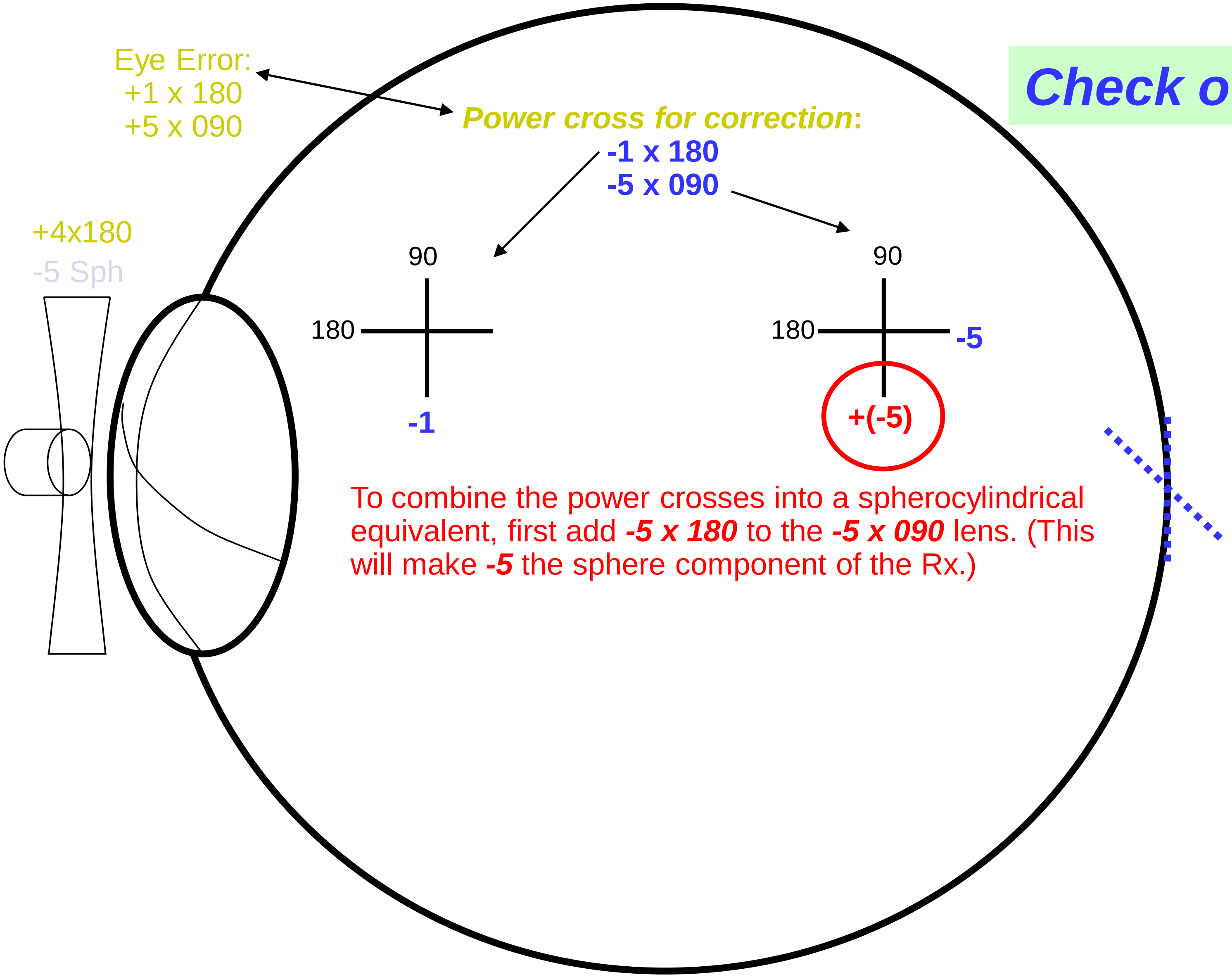


Power Cross

Check our work…



To combine the power crosses into a spherocylindrical equivalent, first add ***-5 x 180*** to the ***-5 x 090*** lens. (This will make ***-5*** the sphere component of the Rx.)

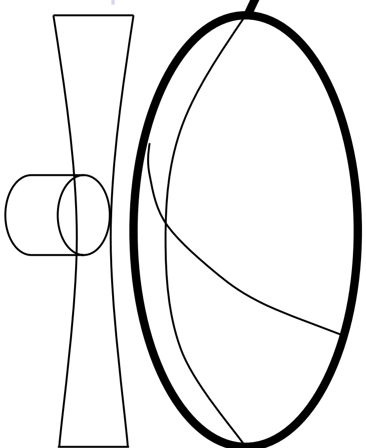
Power Cross

Check our work…

Eye Error:
+1 x 180
+5 x 090

***Power cross for correction*:**
-1 x 180
-5 x 090

+4x180
-5 Sph



90
180
-1 **-(-5) = +4**

90
180 **-5**
+(-5)

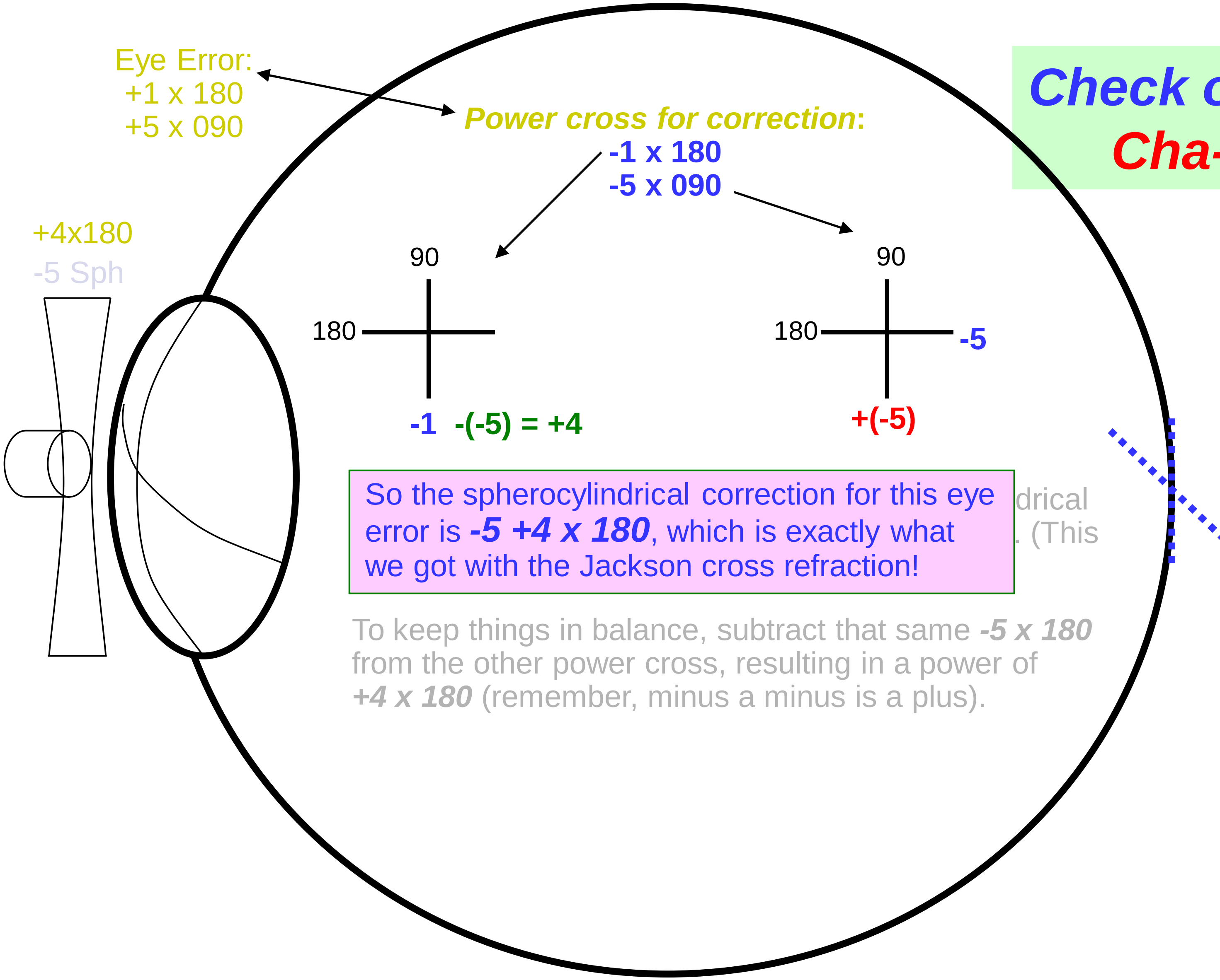
To combine the power crosses into a spherocylindrical equivalent, first add ***-5 x 180*** to the ***-5 x 090*** lens. (This will make ***-5*** the sphere component of the Rx.)

To keep things in balance, subtract that same ***-5 x 180*** from the other power cross, resulting in a power of ***+4 x 180*** (remember, minus a minus is a plus).

Power Cross

Check our work…

Cha-Ching!



So the spherocylindrical correction for this eye error is ***-5 +4 x 180***, which is exactly what we got with the Jackson cross refraction!

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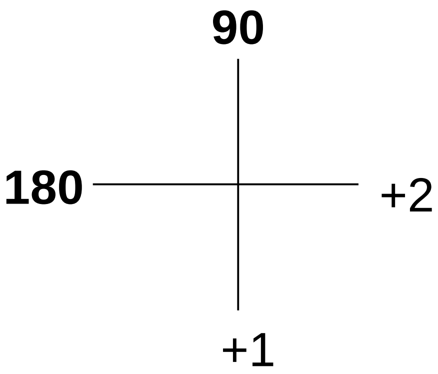
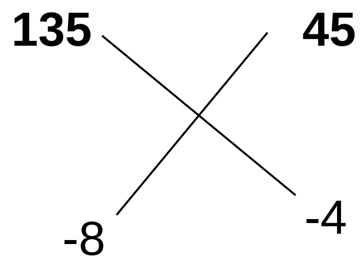
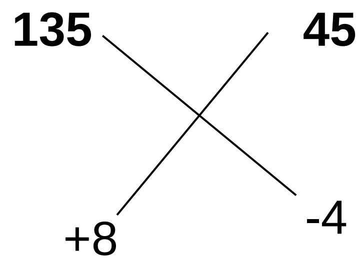
. (This

To keep things in balance, subtract that same ***-5 x 180*** from the other power cross, resulting in a power of ***+4 x 180*** (remember, minus a minus is a plus).

Power Cross

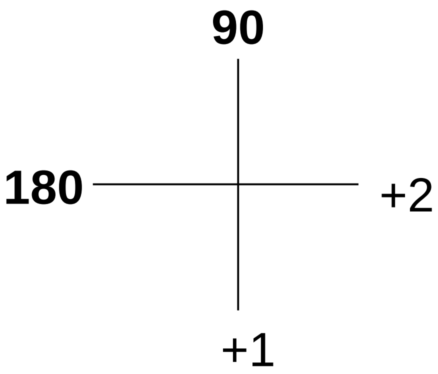






Your turn. These are refractive results (not eye errors). Convert each power cross to spherocylindrical spectacle prescriptions in both plus and minus cylinder formats. Then calculate the S.E. (or can you determine the S.E. simply by looking at the power crosses?)

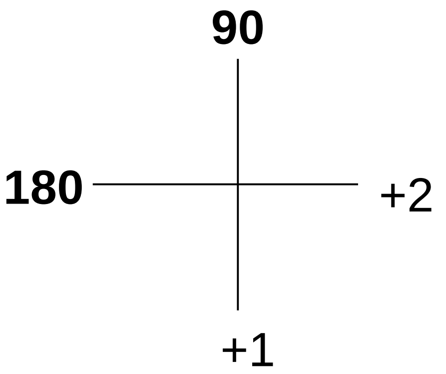
Power Cross



+1.0

If we let the base sphere be +1D…

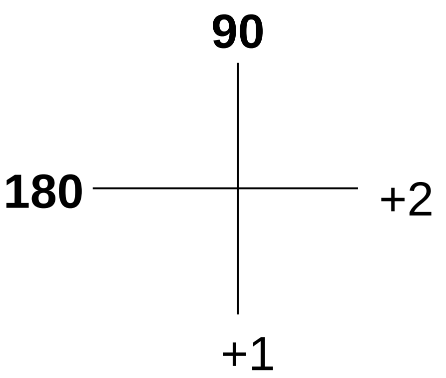
Power Cross



If we let the base sphere be +1D…
we will need an extra +1D at axis 090
to get the +2 power needed there.

Plus cyl: +1.0 +1.0 x 090

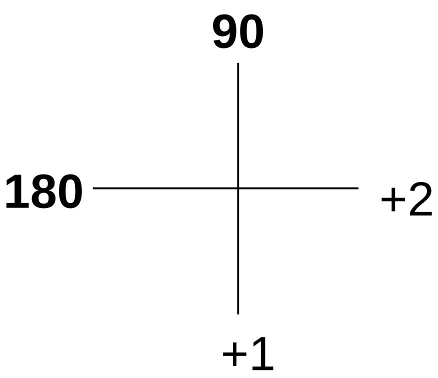
Power Cross



Plus cyl: +1.0 +1.0 x 090
+2.0

If we let the base sphere be +2D…

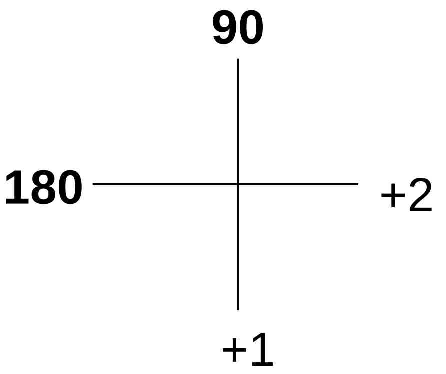
Power Cross



Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 –1.0 x 180

If we let the base sphere be +2D… we will need a -1D at axis 180 to get the +1 power needed there.

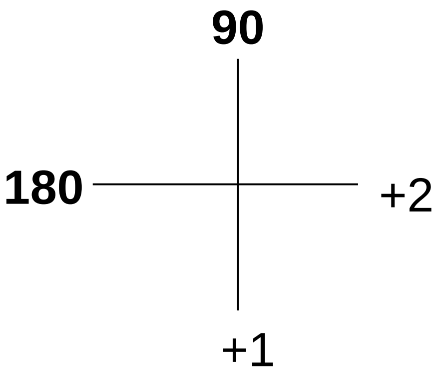
Power Cross



Spherical equivalent = ?

Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 –1.0 x 180

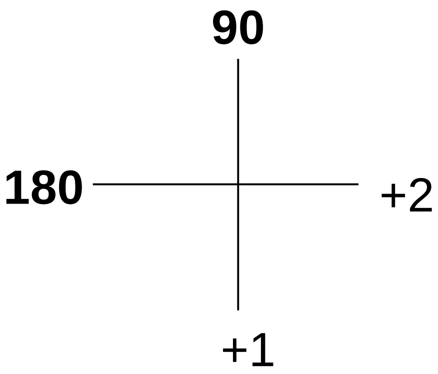
Power Cross



Spherical equivalent = +1 + (+1)/2 = **+1.50**

Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 –1.0 x 180

Power Cross

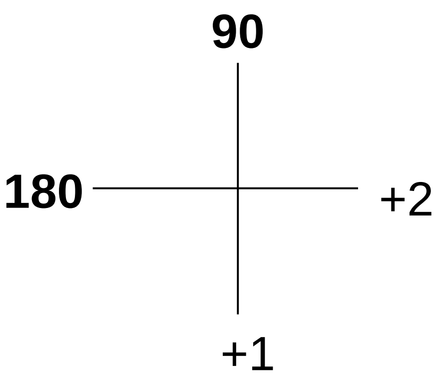


Spherical equivalent = +1 + (+1)/2 = **+1.50**

Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 –1.0 x 180

Spherical equivalent = ?

Power Cross



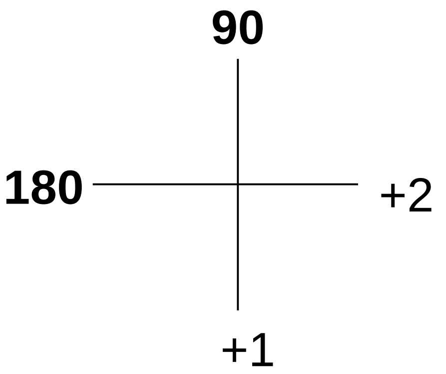
Plus cyl: +1.0 +1.0 x 090

Minus cyl: +2.0 –1.0 x 180

Spherical equivalent = +1 + (+1)/2 = **+1.50**

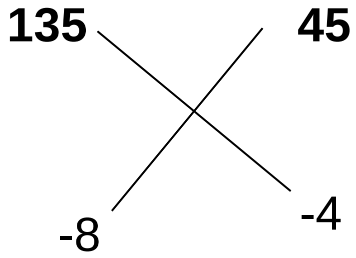
Spherical equivalent = +2 + (-1)/2 = **+1.50**

Power Cross



Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 –1.0 x 180
S.E.: +1.50

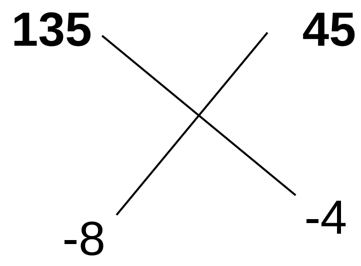
Power Cross



-8.0

If we let the base sphere be -8D…

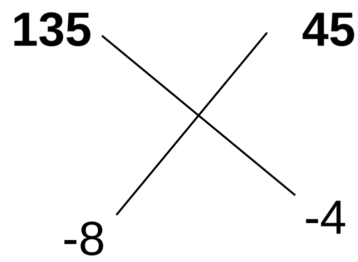
Power Cross



Plus cyl: -8.0 +4.0 x 045

If we let the base sphere be -8D…
we will need an extra +4D at axis 045
to get the -4 power needed there.

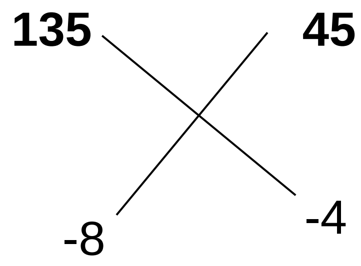
Power Cross



Plus cyl: -8.0 +4.0 x 045
-4.0

If we let the base sphere be -4D…

Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 –4.0 x 135

If we let the base sphere be -4D…
we will need an extra -4D at axis 135
to get the -8 power needed there.

Power Cross

135 **45**

-8 -4

Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 –4.0 x 135

Spherical equivalent = ?

Power Cross

135 **45**

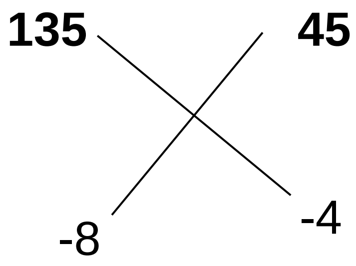
-8 -4

Plus cyl: -8.0 +4.0 x 045

Minus cyl: -4.0 –4.0 x 135

Spherical equivalent = -8 + (+4)/2 = **-6.0**

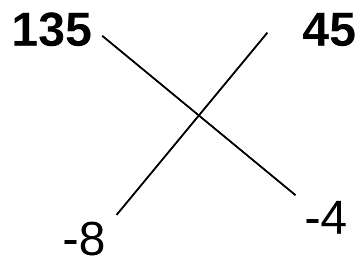
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 –4.0 x 135

Spherical equivalent = ?

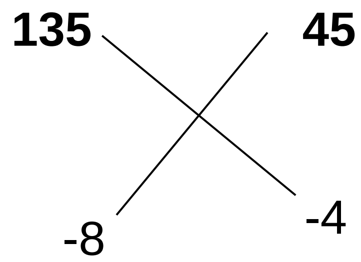
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 –4.0 x 135

Spherical equivalent = -4 + (-4)/2 = **-6.0**

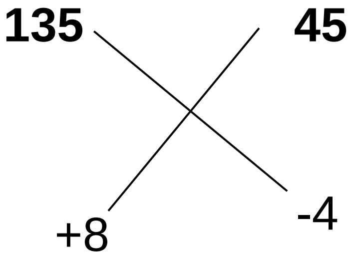
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 –4.0 x 135
S.E.: -6.0

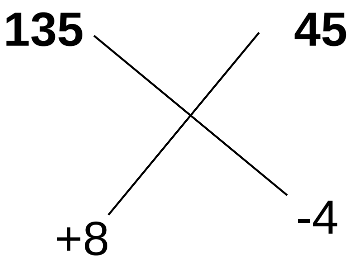
Power Cross

If we let the base sphere be -4D…



-4.0

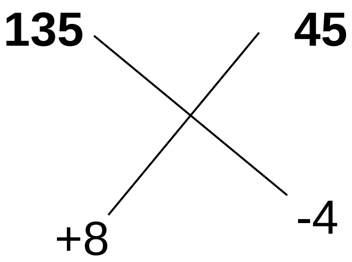
Power Cross



If we let the base sphere be -4D…
we will need an extra +12D at axis 135
to get the +8 power needed there.

Plus cyl: -4.0 +12.0 x 135

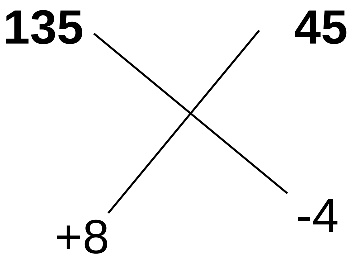
Power Cross



Plus cyl: -4.0 +12.0 x 135
+8.0

If we let the base sphere be +8D…

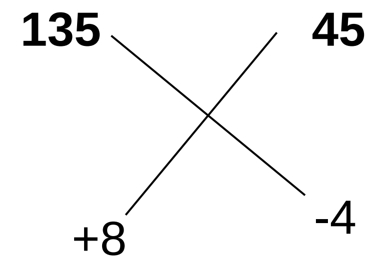
Power Cross



Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 –12.0 x 045

If we let the base sphere be +8D…
we will need an extra -12D at axis 045
to get the -4 power needed there.

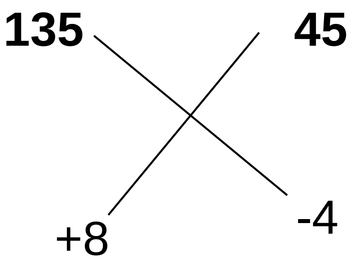
Power Cross



Spherical equivalent = ?

Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 –12.0 x 045

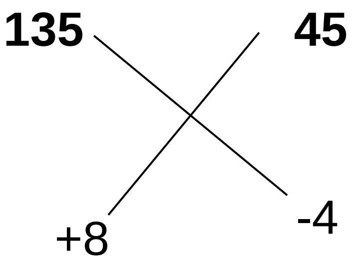
Power Cross



Spherical equivalent = -4 + (+12)/2 = **+2.0**

Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 –12.0 x 045

Power Cross



Plus cyl: -4.0 +12.0 x 135

Minus cyl: +8.0 –12.0 x 045

Spherical equivalent = ?

Power Cross

135 45

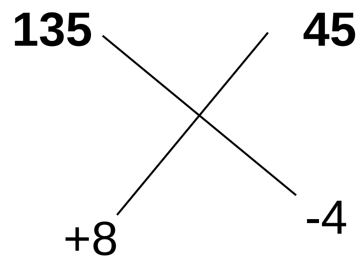
+8 -4

Plus cyl: -4.0 +12.0 x 135

Minus cyl: +8.0 –12.0 x 045

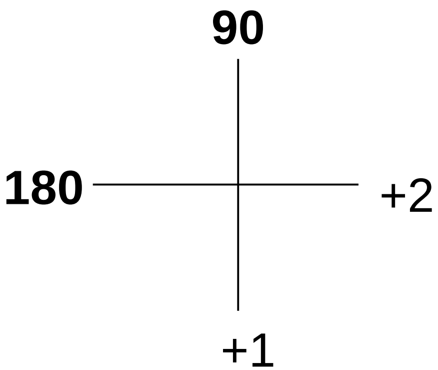
Spherical equivalent = +8 + (-12)/2 = **+2.0**

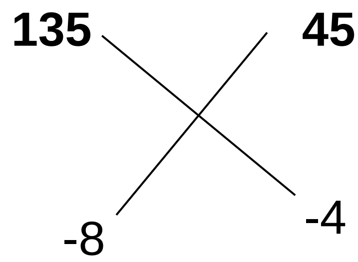
Power Cross

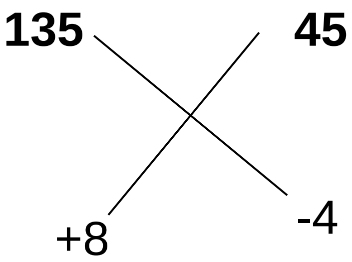


Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 –12.0 x 045
S.E.: +2.0

Power Cross







Plus: +1.0 +1.0 x 090
Minus: +2.0 –1.0 x 180
S.E.: +1.50

Plus: -8.0 +4.0 x 045
Minus: -4.0 –4.0 x 135
S.E.: -6.0

Plus: -4.0 +12.0 x 135
Minus: +8.0 –12.0 x 045
S.E.: +2.0

Note that the S.E., being at the 'dioptric center' of the conoid of Sturm, is simply the halfway point between the two cylinder powers. This can be determined by averaging the cylinder powers—converting to spherocylindrical form first is unnecessary.